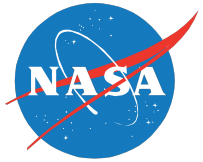
National Aeronautics and Space Administration



Comparison of Anomalies and Trends of OLR as Observed by CERES and Computed from Geophysical Parameters Derived from Analysis of AIRS/AMSU Data

Joel Susskind and Gyula Molnar
NASA GSFC Laboratory for Atmospheres

CERES Science Team Meeting

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Comparison Data Sets

Approach: Comparison of AIRS Version 5 monthly OLR products with CERES monthly mean OLR products for the time period September 2002 through August 2009

Data Used

- AIRS monthly mean data obtained from Goddard DISC (Level 3).
  - Presented on a 1^{o}x1^{o} latitude-longitude grid
  - 1:30 AM and 1:30 PM monthly mean values extracted separately and averaged together

- CERES monthly mean obtained from Langley ASDC
  - All data presented on a 2.5^{o}x2.5^{o} ERBE-like latitude-longitude grid (ES-4)
  - CERES CV Aqua OLR and CERES CV Terra OLR data sets were both available – The higher quality FM1 data were used instead of FM2
    CERES Terra OLR was missing for January and February 2006. Data for each month was generated by interpolation of (CERES Terra OLR) – (CERES Aqua OLR) using December 2005 and March 2006
  - Both data sets include calculations to represent what CERES "would have observed" if measurements were made over the course of a whole day

- Therefore comparison of AIRS OLR with CERES Aqua OLR or CERES Terra OLR is equally valid

Significance of AIRS OLR and OLR_{CLR}

AIRS OLR is a computed product for each AIRS FOR using an OLR RTA

- Input data is AIRS retrieved T_{skin}, ε_ν ,T(p), q(p), O_3, α, and p_{cloud}

AIRS OLR_{CLR} is also computed for each AIRS FOR using same retrieved parameters but setting $\alpha = 0$

CERES OLR is a measured product

If anomalies and trends of AIRS OLR closely match those of CERES OLR, then

- This validates anomalies and trends of both AIRS OLR and CERES OLR
- This indirectly validates anomalies and trends of AIRS retrieved products
- Most importantly, anomalies and trends of OLR can now be attributed to those of its component parts

Definition of Anomalies and Trends Over the 7 Year Time Period

7 year monthly climatologies were generated for each grid box by averaging data for 7 Januaries, 7 Februaries, …

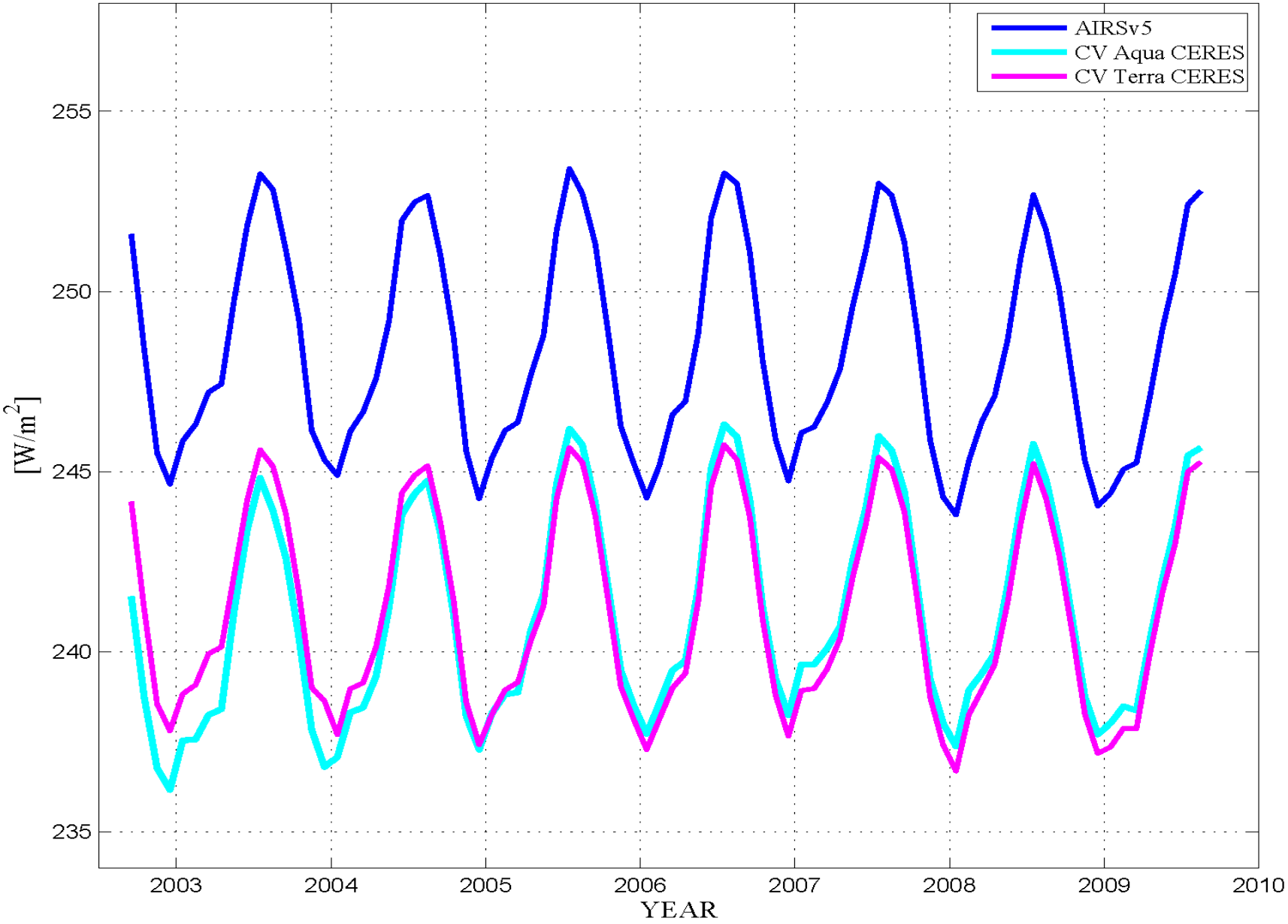
The monthly anomaly for each grid box is the difference of the value for that month from its climatology

The trend for a grid box is the slope of the straight line passing through the 84 monthly anomalies

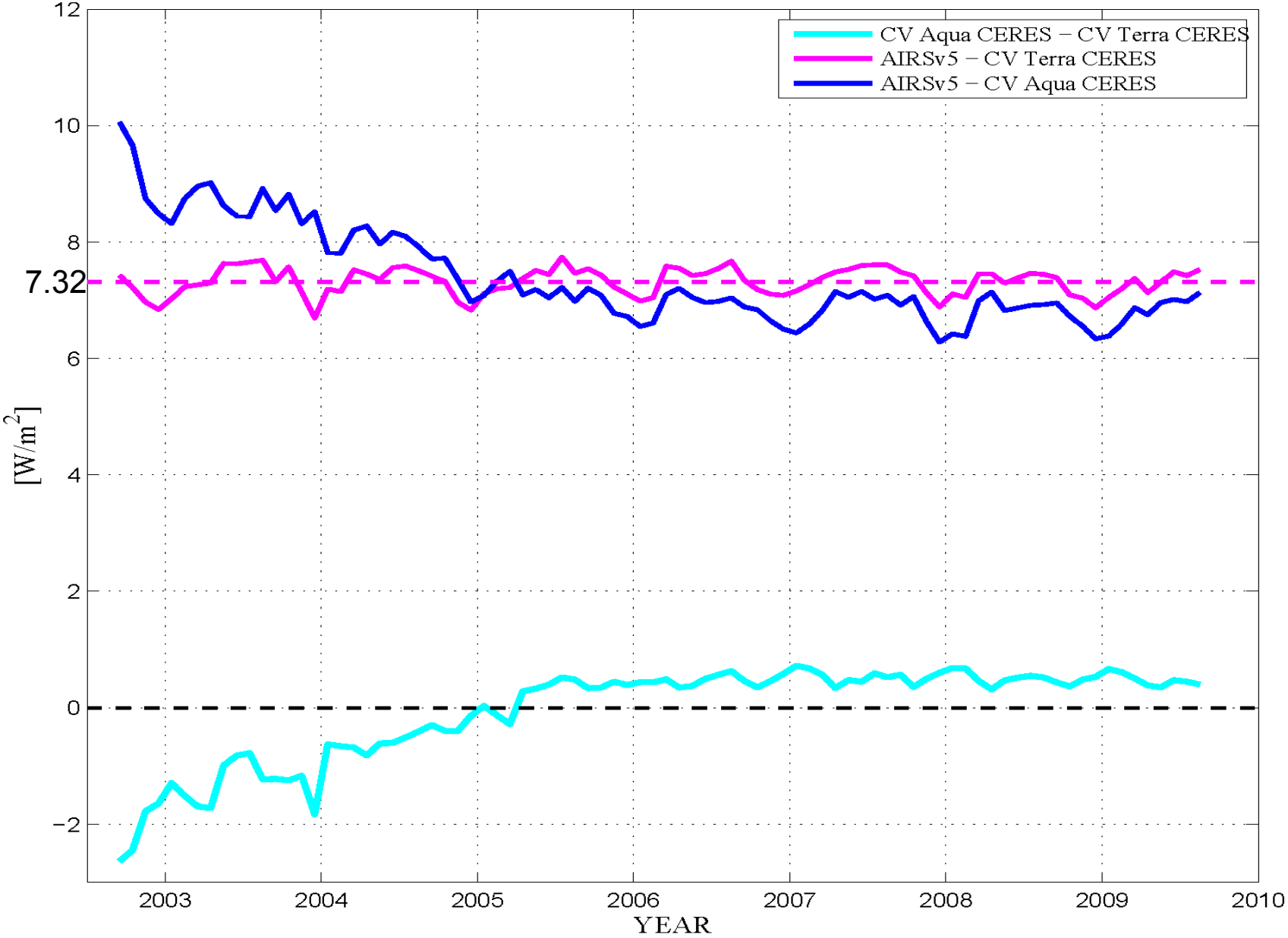
The area mean trend is the cosine latitude weighted average trend over the area

Anomalies and trends of AIRS and CERES OLR can match well if there is a bias between AIRS and CERES OLR but it is essentially constant in time

September 2002 through August 2009 Time Series of Global All-Sky OLR



September 2002 through August 2009 Time Series of Global All-Sky OLR Differences



Findings from Time Series of Global OLR

CERES Terra and CERES Aqua match well after March 2005

- Ceres Aqua OLR is increasingly lower than CERES Terra before March 2005
- This will result in significantly different trends obtained from CERES Terra and CERES Aqua

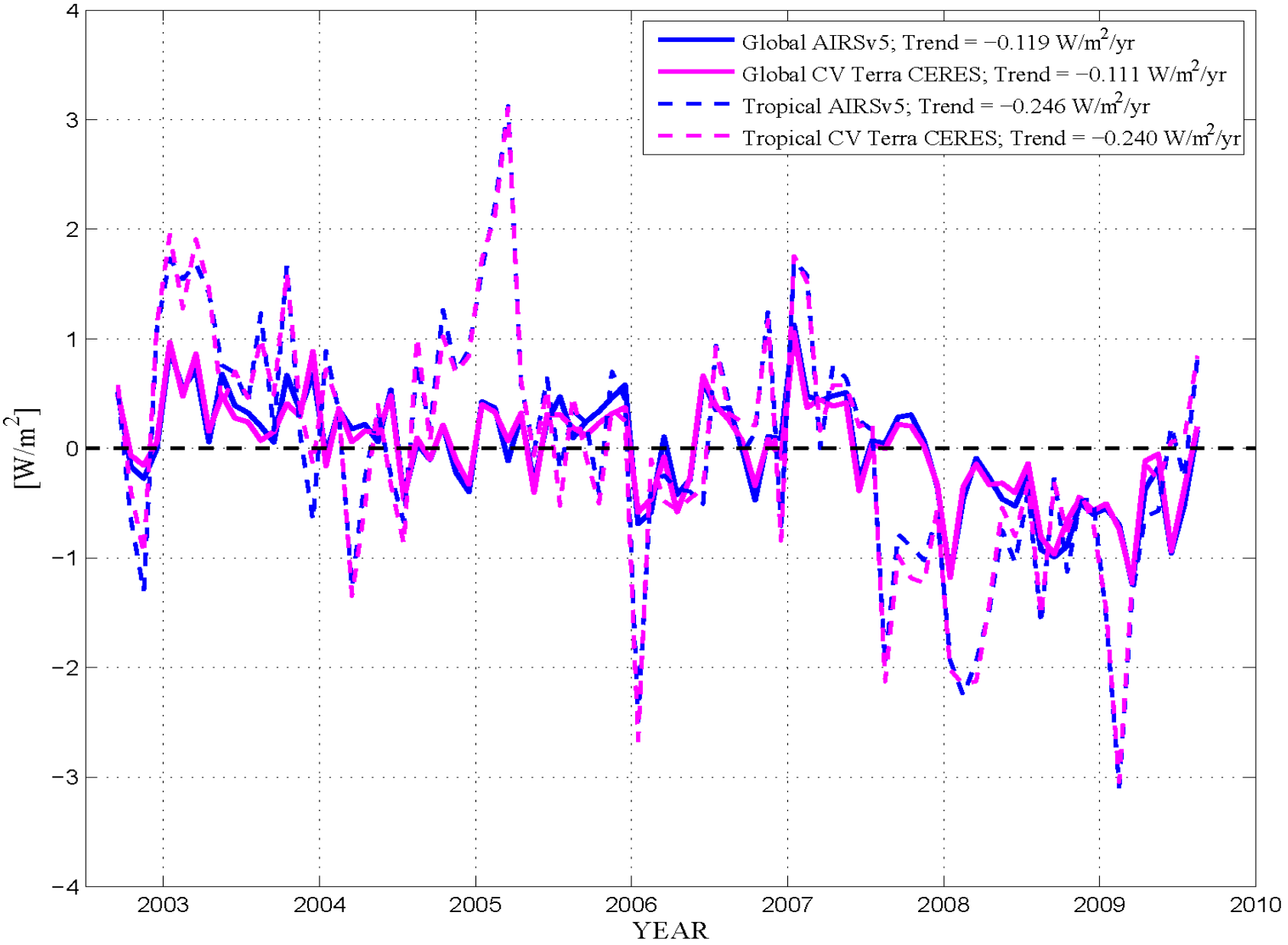
AIRS OLR and CERES Terra OLR are biased by about 7 W/m^2, with a small seasonal cycle

- This bias is essentially constant over the 7 year time period
- This implies global mean trends of AIRS and CERES Terra OLR might agree well
- To first order, both the large bias and its small seasonal cycle will be removed in the anomaly time series

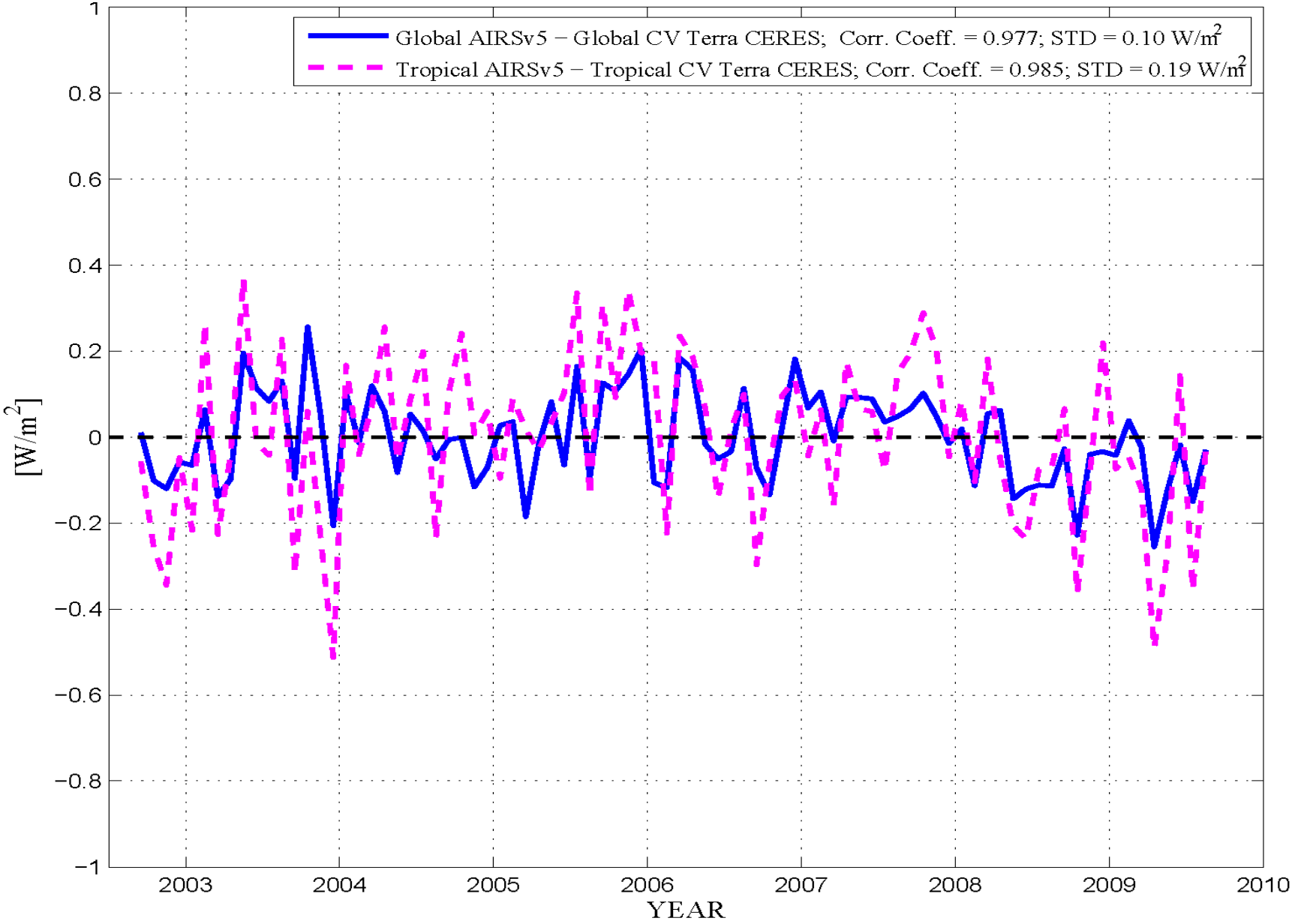
Version 6 OLR uses a new OLR RTA that essentially removes the bias between AIRS and CERES

- The new RTA was developed by AER
  - The improvement is mainly in the characterization of the H_2O rotation band near 300 cm^{-1}

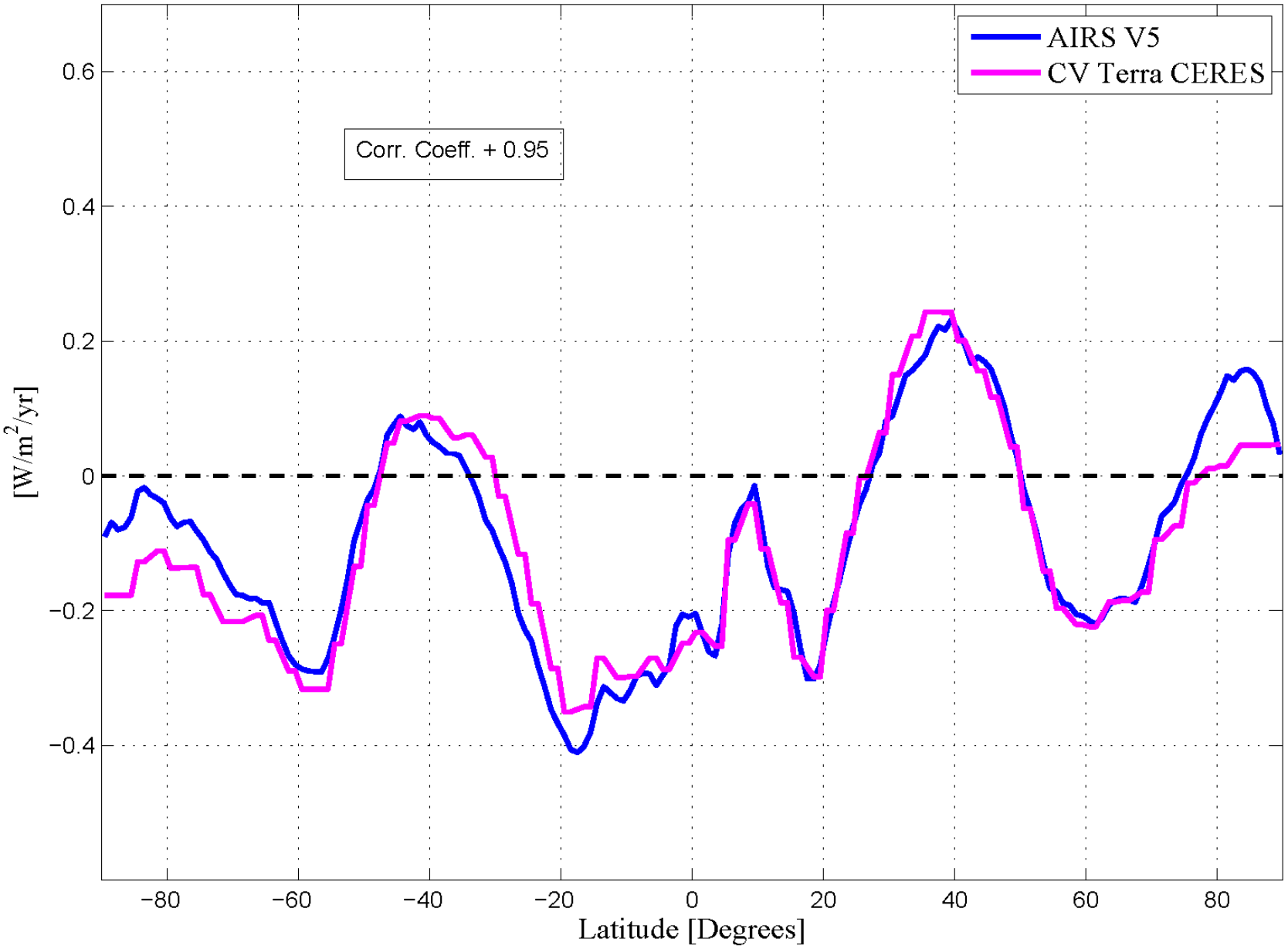
September 2002 through August 2009 All-Sky OLR Anomaly Timeseries



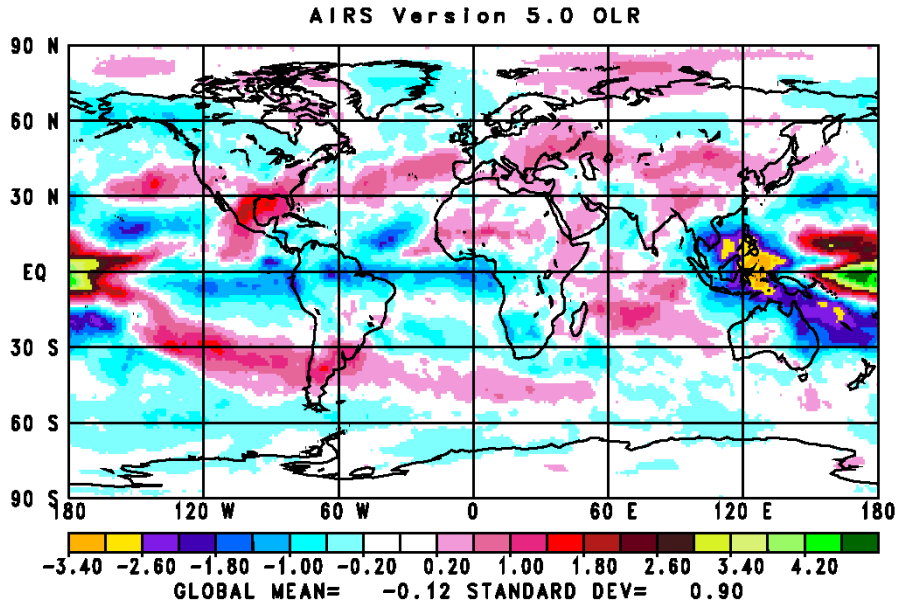
September 2002 through August 2009 All Sky OLR Anomaly Timeseries Differences

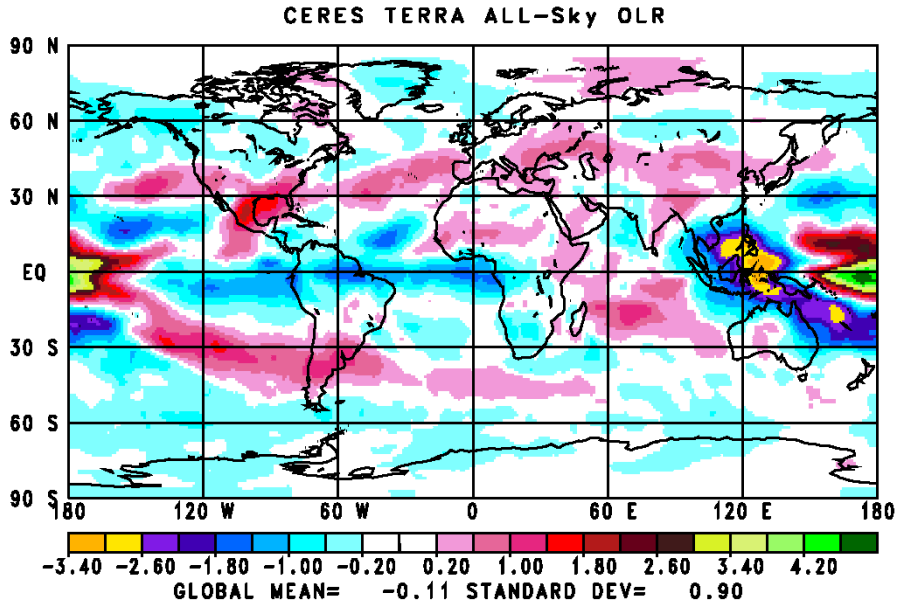


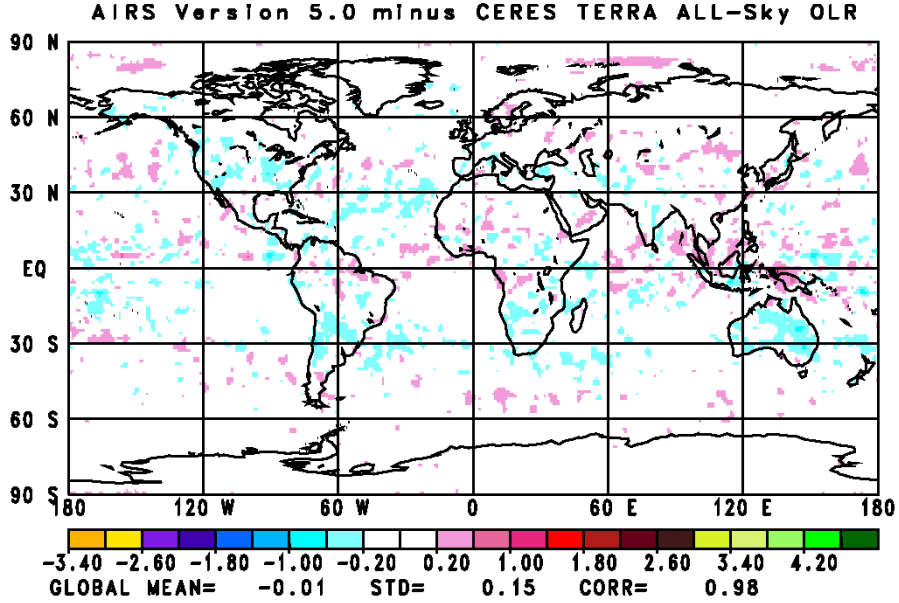
Zonal Mean September 2002 through August 2009 OLR Anomaly Trends [W/m^2/yr]



OLR "Trend" (W/m²/yr)
September 2002 through August 2009

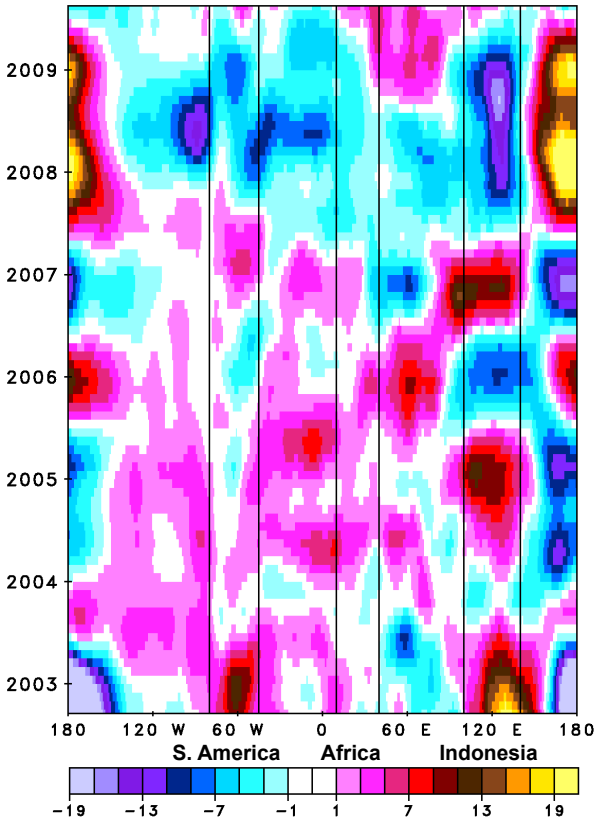




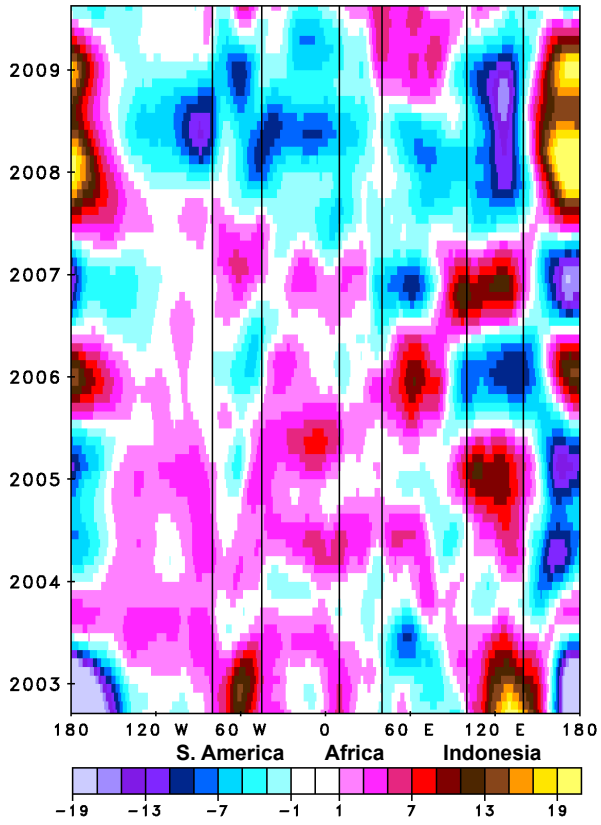


OLR Anomaly (Watts/m^2)
Tropics 5^{o}N to 5^{o}S
Monthlies, September 2002 through August 2009

AIRS

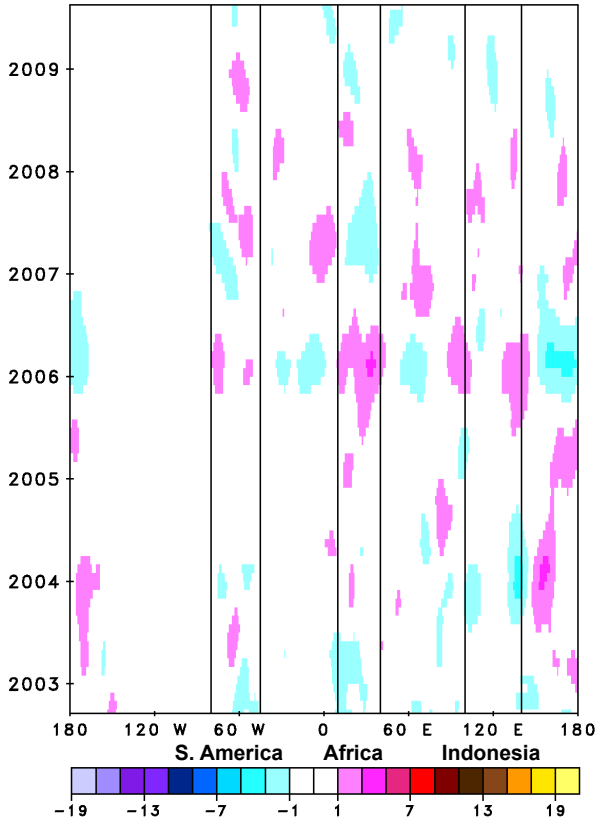


CERES Terra



AIRS minus CERES Terra

Correlation = 0.96



Comparison Summary

AIRS and CERES Terra OLR anomalies and trends agree well in every detail in the 7 year period under study

Agreement of all details of anomalies and trends determined by CERES and AIRS imply they all are real

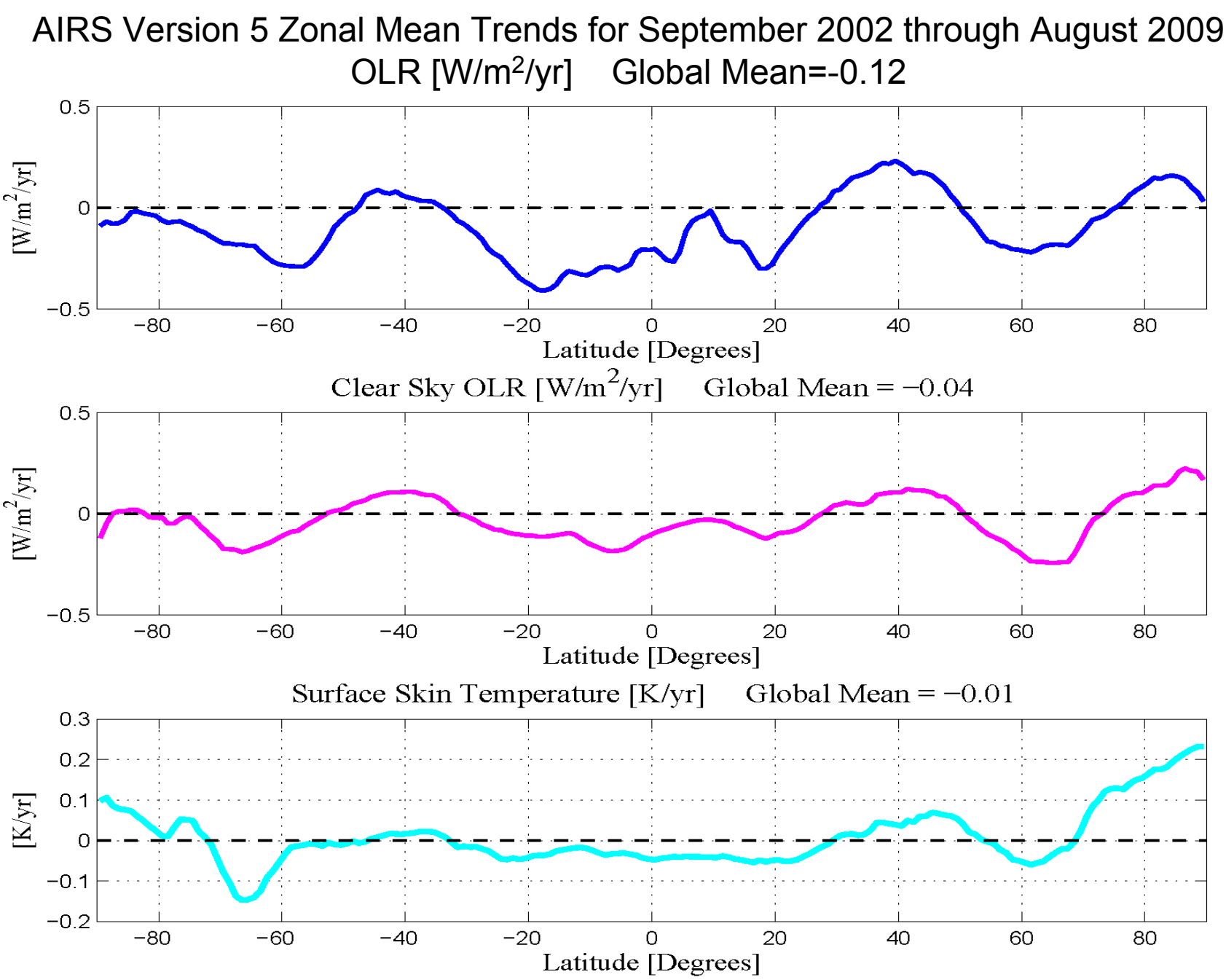
There is a decrease in global OLR of -0.12 Wm^2/yr over this time period
The majority of this global decrease originates in the tropics

OLR trends over this time period cannot be used to predict future long term OLR trends

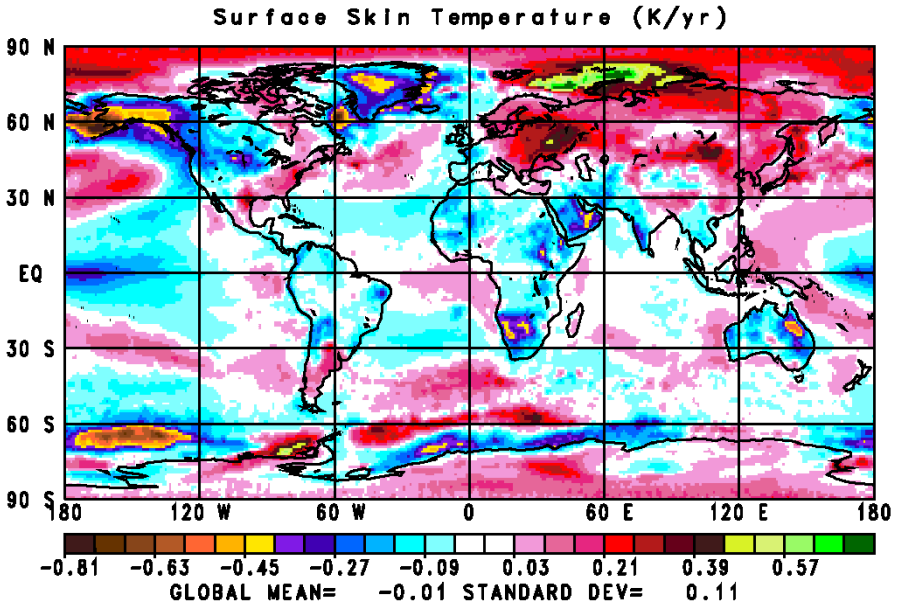
It is desirable to maintain CERES and AIRS class instruments to corroborate and verify future OLR measurements.

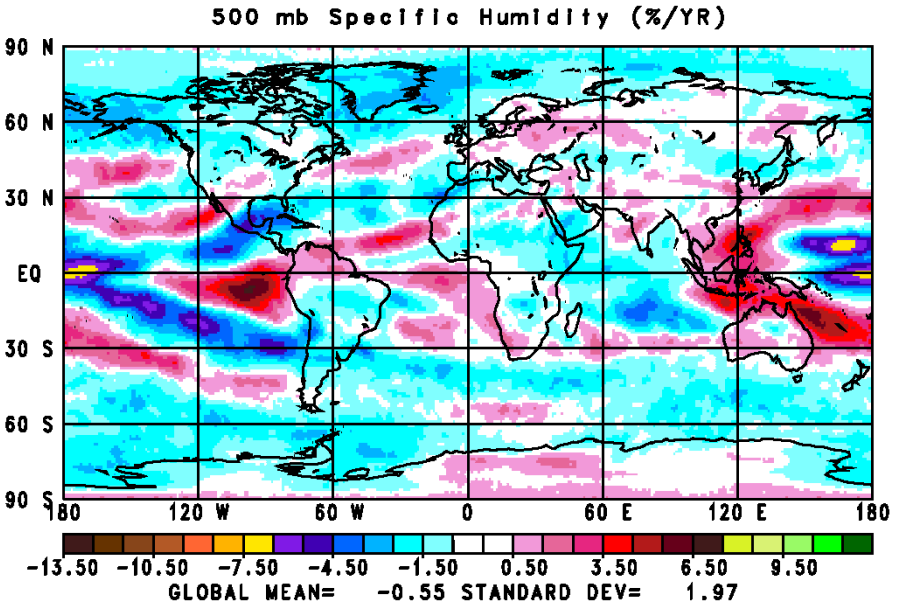
The following results using AIRS products show that most of the OLR trends seen during this period result from El Niño/La Niña cycles

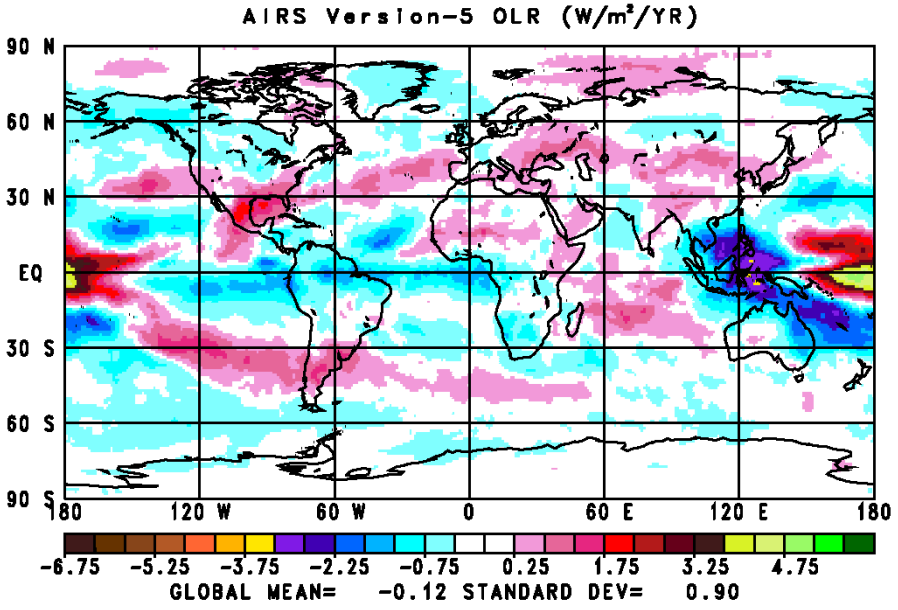
AIRS Version 5 Zonal Mean Trends for September 2002 through August 2009

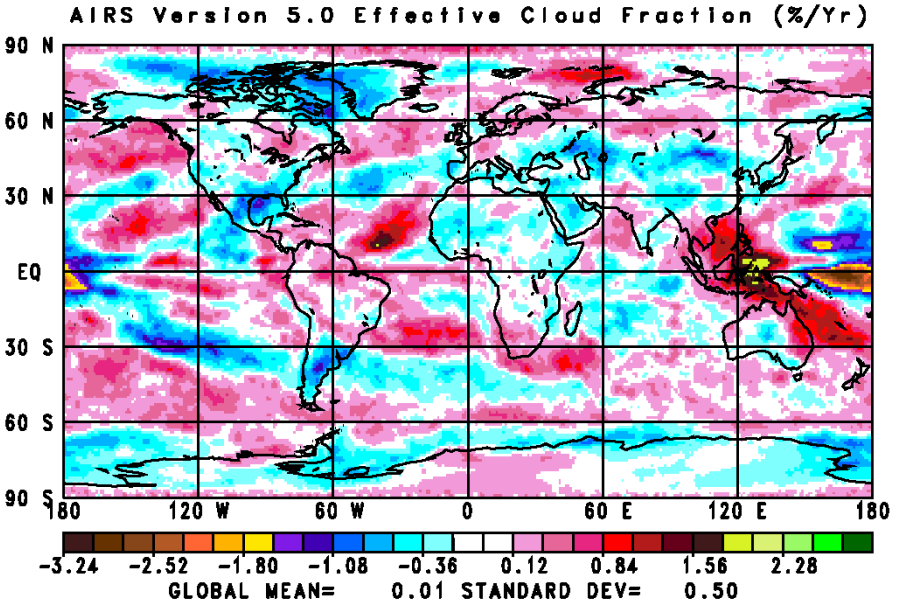


AIRS Version 5.0 Anomaly "Trend"
September 2002 through August 2009





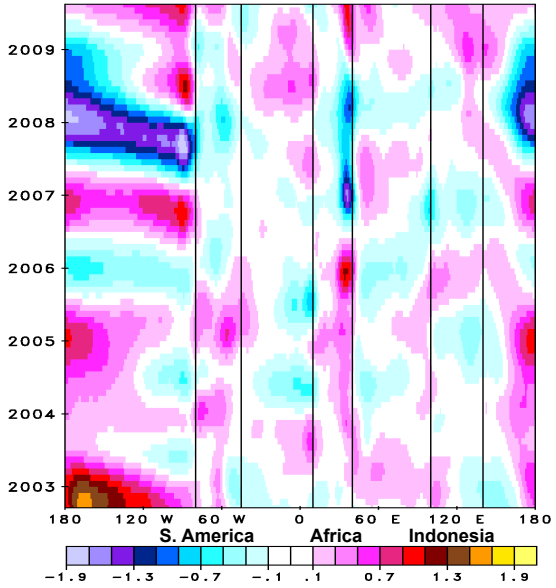




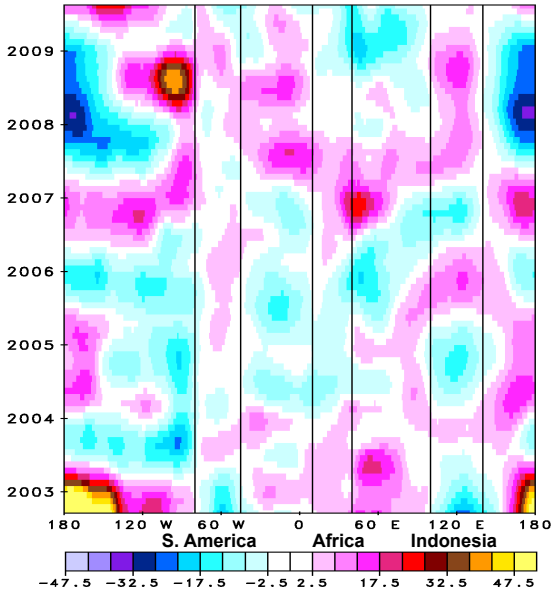
Monthlies
September 2002
through
August 2009

Tropics
5°N to5°S

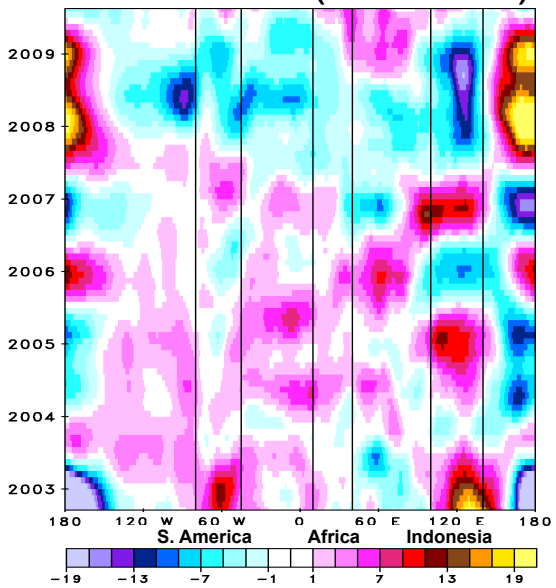
Surface Skin Temperature (K)



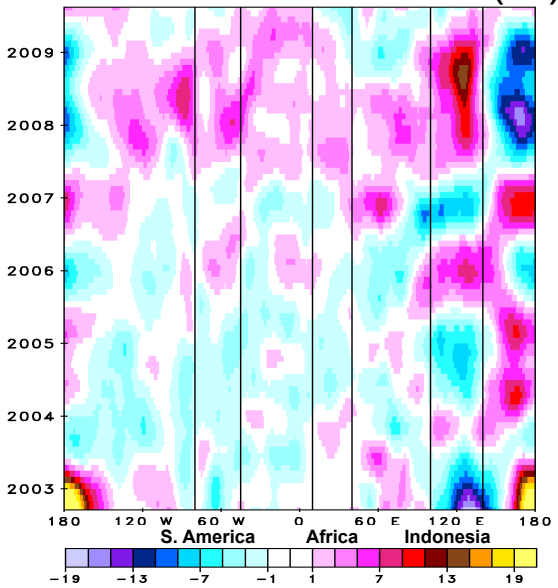
500 mb Specific Humidity (%)



AIRS OLR (Watts/m^2)



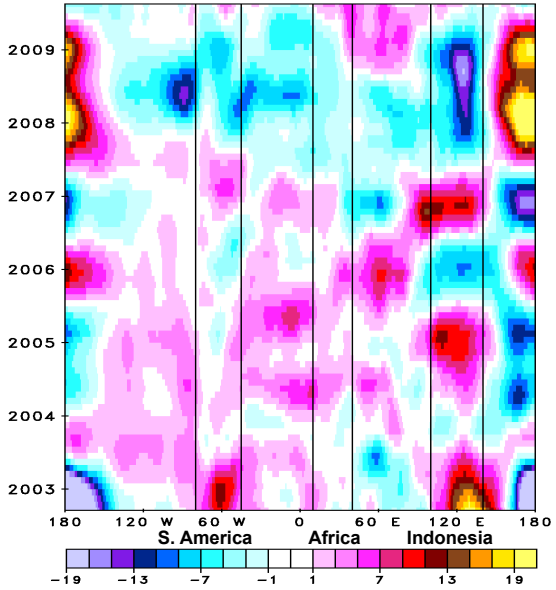
AIRS Cloud Fraction (%)



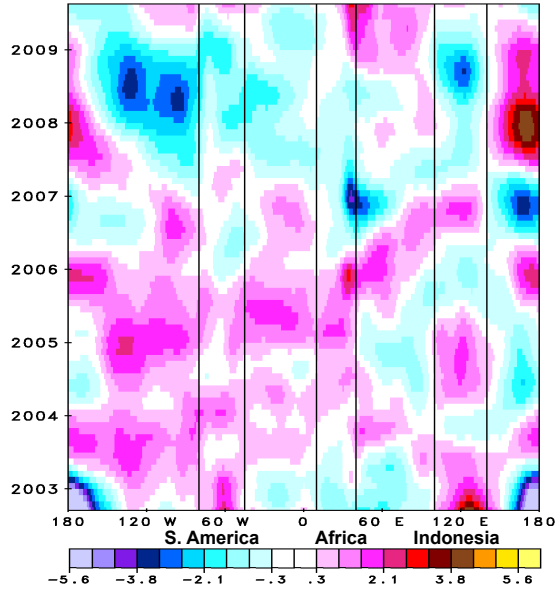
Monthlies
September 2002
through
August 2009

Tropics
5°N to5°S

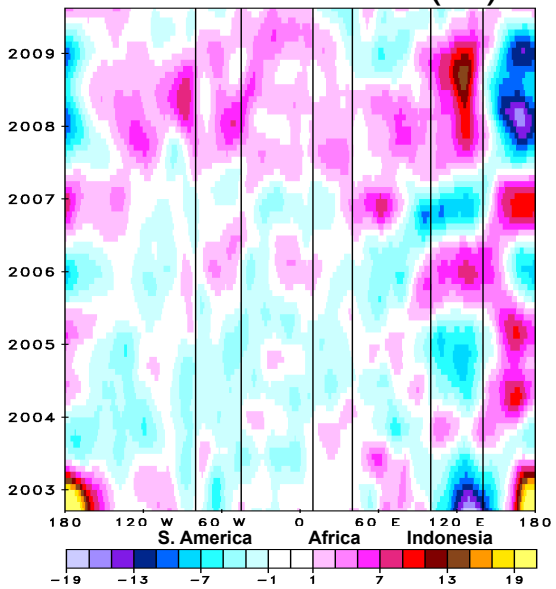
AIRS OLR (Watts/m^2)



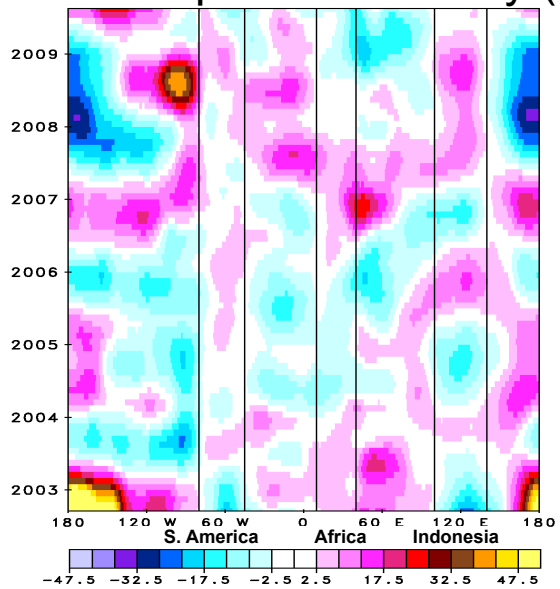
AIRS Clear Sky OLR (Watts/m^2)



Cloud Fraction (%)



500 mb Specific Humidity (%)



Propagation of Tropical T_{skin}, q(500), and α Anomalies

T_{skin}

The largest anomalies occur between 160°E and 60°W

September 2002 was the height of a strong El Niño period

February 2008 was the height of a strong La Niña period

Late 2008 has warm SST anomalies off the west coast of South America,
and cold anomalies near the dateline

Mid 2009 is the beginning of a full El Niño

q(500)

Specific humidity anomalies closely follow T_{skin} anomalies near the dateline

Water vapor near the dateline decreases significantly during the La Niña

Water vapor is shifted eastward-increasing west of South America and over Indonesia during the La Niña, but decreasing in the Indian Ocean

Cloud fraction α

Cloud fraction anomalies are highly correlated with q(500) anomalies

Both near and away from the dateline

Effects of El Niño/La Niña Oscillation on Tropical OLR and OLR_{CLR} Anomalies and Trends

Topical OLR and OLR_{CLR} anomalies are highly correlated with each other and negatively correlated with q(500) and α anomalies

The El Niño/La Niña oscillation results in a tropical zonal mean T_{skin} cooling trend

The El Niño/La Niña oscillation corresponds to a tropical zonal mean decrease in OLR and OLR_{CLR}

These two phenomena are indirectly related

Decreasing water vapor and cloud cover in the La Niña area increases OLR in this region

This is more than compensated by increasing water vapor elsewhere, lowering the zonal mean tropical OLR during La Niña